Hydrologic Model Manager

Short Name	CASC2D
Long Name	CASCade of planes, 2-Dimensional
Description	
Model Type	Simulation of spatially-varied Hortonian watershed hydrology and erosion/sediment transport for hydrologic scientific studies and detailed engineering analyses. Solution of problems where spatial-variability of watershed characteristics, rainfall, runoff, and erosion is important.
Model Objectives	
Agency Office	Model development funded by US Army Research Office and US Army Corps of Engineers, Engineer Research and Development Center.
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Model Structure	CASC2D is a square-grid (raster) hydrologic model that solves the equations of transport of mass, energy, and momentum between model grid cells using a finite difference formulation. The model formulation is entirely spatially-varied in that all parameters and inputs can vary from one grid to the next. The model formulation is continuous, and includes: evapotranspiration; rainfall input; empirical rainfall interception; optional Green and Ampt (I 91 1) or Green and Ampt with redistribution (GAR) (Ogden and Saghafian 1997) infiltration; two-dimensional diffusive-wave overland flow routing; one-dimensional diffusive wave channel flow routing in natural cross-sections; Kilinc-Richardson (1973) empirical overland erosion; overland sediment transport and deposition; and bed- and suspended-load sediment routing in channels.
Interception	
Groundwater	
Snowmelt	
Precipitation	
Evapo-transpiration	
Infiltration	
Model Paramters	Interception storage and coefficient; soil saturated hydraulic conductivity; soil wetting front capillary head; soil effective porosity; soil initial water content; soil residual water content; soil wilting point water content; soil pore distribution index; land surface albedo; vegetation height; radiation transmission coefficient; plant canopy resistance; root-zone depth; overland flow Manning roughness coefficient; overland flow retention depth; channel Manning

	roughness coefficient; overland soil erosivity; overland soil conservation practice factor; overland soil cropping factor.
Spatial Scale	The model has been used to simulate watersheds from 0.016 to 2300 km2 in area. CASC2D models have been developed with grid sizes ranging from 10 to 1000 m. The model is typically applied at grid sizes ranging from 30 to 125 m.
Temporal Scale	CASC2D can be run in a single-event mode, or in continuous mode. Continuous simulations can be run for an indefinite period of time. Model computational time-steps for numerical stability range from I second to 20 seconds, depending upon the grid size and rainfall intensity. The model time step is I hour between rainfall events when no surface routing is required.
Input Requirements	Topography in the form of a raster digital elevation model; rainfall rates from gages, weather radar, or meteorological model; meteorological variables for continuous simulations (temperature, relative humidity, wind speed, solar radiation); channel cross-sections; initial soil moisture content, if known.
Computer Requirements	CASC2D is a hydrodynamic model. As such, the model runs best on computers with high-speed processors. The specific speed of the model is defined as the ratio of the wall clock time for a simulation to run (seconds) divided by the following terms: simulation duration in weeks, number of computational grid points in the watershed, computational time step (seconds), and floating point performance of the computer in million floating point operations per second (MFLOPS). The specific speed of CASC2D is approximately 6 x I 0-5 week-1 MFLOP-1 grid-1. For instance, CASC2D running in the continuous mode over a six week period of record on a watershed with 1357 grid points, with a computational time step of 10 seconds, requires approximately 660 seconds to run on a 129 MFLOP 550 MHz Intel Pentium III workstation. Memory requirements are approximately equal to the number of grid cells multiplied by the number of spatially-varied input maps time the number of bytes in a floating point number (typically 4).
Model Output	The default output from CASC2D is an output hydrograph at the watershed outlet and a summary file that details the mass-balance of the simulation. Optional output includes: sediment (suspended load and bed load) hydrographs at the catchment outlet; flow and sediment hydrographs at internal catchment locations; a time-series of spatially-varied output maps of: overland flow depth; channel flow depth; overland erosion/deposition; and land-surface soil moisture.
Parameter Estimatn Model Calibrtn	The Shuffled Complex Evolution (SCE) automated calibration procedure (Duan et al. 1992) was successfully employed by Senarath et al. (2000) to calibrate CASC2D in continuous simulations. Published tables of parameter values (e.g. soil infiltration and overland roughness parameters) usually provide good initial values. GIS can be used to describe the spatial distribution of parameters using land-use/land-cover and soil textural classifications.
Model Testing Verification	The formulation of CASC2D was extensively tested and verified at each step of development. Individual process models (e.g. overland flow, channel flow, infiltration, overland erosion) were individually verified using field or laboratory data where available before inclusion in CASC2D. The entire model formulation has been evaluated on a number of watersheds in single-event and continuous simulations by the developers and the US Army Corps of Engineers, Engineer Research and Development Center.
Model Sensitivity	The most sensitive model parameters are: overland flow Manning roughness coefficient, channel flow Manning roughness coefficient, soil saturated hydraulic conductivity; overland flow retention depth; and plant canopy resistance. The model is quite sensitive to errors in rainfall rate.
Model Reliabiity	CASC2D produces accurate spatially-varied simulation results in Hortonian watersheds where the influence of groundwater on runoff production is negligible. The performance of CASC2D improves as rainfall intensity increases, making CASC2D an excellent model for flood predictions and forecasting in urban areas. Model reliability is closely related to the quality and quantity of calibration/verification data available. Errors in the space-time distribution of rainfall due to inadequate rain gage density or radar-rainfall estimation errors are typically amplified through runoff predictions (Sharif et al. 2000).

Model Application	Watersheds where the CASC2D model has been applied include: Macks Creek, Idaho; Taylor Arroyo and Spring Creek, Colorado; Goodwin Creek and Hickahata-Senatobia watersheds, Mississippi; Henson Creek, Texas, Cave Creek and Hassyampa watershed, Arizona; Rapidan River, Virginia; urban watersheds in Trenton, New Jersey, and Charlotte, North Carolina; Little Washita watershed, Oklahoma; Rapidian River, Virginia; Myjava basin, Jalovecky Creek and Turzovka basin, Slovakia; Salzbach watershed, Switzerland; and the upper Rio Chagres watershed in Panama. (See bibliography at the end of this list).
Documentation	Documentation exists for CASC2D Version 1. 1 8 (Ogden 1998), which includes model details related to: hydrologic simulations, continuous formulation, and overland/channel erosion, sediment transport, and deposition.
Other Comments	CASC2D uses S.I. units, and the Universal Transverse Mercator UTM map projection system. The model is supported by the U.S. Department of Defense Watershed Modeling System (WMS) hydrologic model interface developed at Brigham Young University. WMS has import/export capabilities with both the ARC/INFO and GRASS Geographic Information Systems. The WMS has functionality specifically for creating CASC2D input data sets including: topographic analysis using TOPAZ (Garbrecht and Martz 1997), stream cross-section pre-processor, stream profile smoothing tools, and map creation/manipulation capabilities. CASC2D input maps use the GRASS ascii format. WMS and GIS are not required for using CASC2D but are helpful in data set creation. Model Bibliography: DeBarry, P., et aL, 1999, GIS Modules and Distributed Models of the Watershed, ASCE Task Committee Report, American Society of Civil Engineers, Reston, Va, USA, 20191, ISBN: 0-7844-0443-7,120 pp. Doe III, W.W., P.Y. Julien, F.L. Ogden and B.E. Johnson, 1998, Spatially-distributed modeling of the hydrologic effects of mechanized maneuvers on military training lands, Proc. of the First Interagency Hydrologic Modeling Conference, Las Vegas, April 19-23, Section 8, pp. 27-34 Doe III, W.W., B. Saghafian, and P.Y. Julien, 1996, Land-use impact on watershed response-. the integration of two-dimensional hydrologic modeling and Geographic Infon-nation Systems, J. Hydrol. Processes, 10: 1503 -1511. Doe III, W. W., and B. Saghafian, 1992, Spatial and temporal effects of army maneuvers on watershed response: The integration of GRASS and a 2-D hydrologic model, In: Proc. 7th Annual GRASS Users Conference, National Park Service Technical Report NPS/NRG15D/NRTR-93/13, Lakewood, Colorado, pp. 91-165. Downer, C.W., F.L. Ogden, W. Martin, and R.S. Hannon, 2000, The use of Hortonian, Physically Based Hydrologic Models in the US Army: Theory, Development, and Implementation of the Hortonian Model C,4SC2D, submitted for publication, Hydrologic Processes. Duan, Q., S. Sorooshian and V. Gupta, 1992, Effective and efficient global optimization for conceptual rainfall-runoff models, Water Resour. Res., 28(4): 1015-1031. Garbrecht, J., and L. W. Martz. 1997. TOPA7-: An Automated Digital Landscape Analysis Tool for Topographic Evaluation, Drainage Identification, Watershed Segmentation and subcatchments Parameterization; TOPAZ Overview. U.S. Department of Agriculture, Agricultural Research Service, Grazinglands Research Laboratory, El Reno, Oklahoma, USA, ARS Publication No. GRL 97-2, 21 pp., April 1997. Johnson, B.E., P.Y. Julien and C.C. Watson, 1998, Development of a storm-event based two- dimensional model (CASC2D-SED), First Interagency Hydrologic Modeling Conference, Las Vegas, April 19-23, Section 3, pp. 39-46. Johnson, B.E., 1997, Development of a Storm Event Based Two-Dimensional Upland Erosion Model, Ph.D. Dissertation, Colorado State University, Fort Collins, CO 80523, 253 pp.

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